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THE INFLUENCE OF CHEMICAL THOUGHT ON BIOLOGY[1]

By Sir FREDERICK GOWLAND HOPKINS

SIR WILLIAM DUNN PROFESSOR OF BIOCHEMISTRY, UNIVERSITY OF CAMBRIDGE; PAST PRESIDENT OF THE ROYAL SOCIETY, LONDON, AND OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE latter half of the last century, though a period of such rapid progress alike in physical and biological science, saw inadequate contact between the thought of the chemist and that of the biologist.

It is true, and a familiar circumstance to those with an interest in the history of science, that, when that half century began, organic chemistry and what we now term biochemistry were both yet in embryo and were hardly to be distinguished. Justus von Liebig fathered them both.

It was the genius of Liebig that started modern organic chemistry on a triumphant career, and Liebig's great desire and one which directed his own efforts was to see chemistry render full service to animal physiology and to agriculture. This desire, in satisfactory measure, was not fulfilled during Liebig's own lifetime, and it is, I think, of some historical interest to decide why during years when scientific minds were so alert so promising a field was cultivated by so few. At first I think certain personal attributes in leaders of thought contributed to the separation of chemistry from biology. Liebig himself, for instance, though so brilliant a chemist, lacked biological training and, as I have always felt, a biologist's instincts. When with great enthusiasm he came to apply his chemical knowledge to the living plant and animal his thought often went obviously astray, and much of his theoretical teaching was instinctively and rightly rejected in biological thought. What was really so valuable in that teaching lost therefore some of its influence. Strange as it may seem, the influence of that other dominant mind of the time, that of

[1] Given at the Harvard Tercentenary Conference of Arts and Sciences, September 8, 1936.

Pasteur, did not altogether favor an approach between chemist and biologist. If Liebig remained too much the chemist, Pasteur, once he entered, with such immense profit to science, the biological field, became almost too much a biologist, at least in so far as he favored the current belief that the activities of a living organism could be understood only by thinking in terms of that organism as a whole. Any analysis of its totality he held to be of little avail.

Although such influences played a part, as did the prejudice of some leading biologists, the chief factor which delayed an approach to biology from the chemical side was doubtless the extreme vigor of the young science of organic chemistry itself. Extraordinary enthusiasm followed immediately upon the activities of Liebig, and the rapid development of the magical synthetic art of the chemist provided him with substances made not by nature but by himself, with properties especially suitable for the development of clear ideas concerning molecular structure. To gain these was the enthusiastic and highly successful effort of the time. There was therefore for a long while relatively little temptation to approach the plant or animal for new material, an approach which might have reawakened biological interests in the mind of the chemist.

Meanwhile the times were not ripe for a serious approach from the side of biology. Zoology and botany were still essentially observational and descriptive sciences, while chemistry was necessarily experimental, a circumstance which in itself helped in their divorce. In the history of biology it was of course inevitable that the study of form should precede the study of function, and it is not surprising that concern with the molecular events which must underlie all displays of active function should come still later.

Moreover, at the very time when Liebig was engaged in urging the claims of chemistry on biological thought, the long and intelligent study of plant and animal forms in nature at large reached its great triumph in establishing the truths of evolution which so profoundly influenced scientific thought. It is not surprising that this new outlook and the many suggestions it gave for yet closer study of morphological differentiation and adaptation left the general biologist preoccupied with the manifestations of form for many years longer.

On the other hand, vertebrate physiology, starting as the handmaid of medicine, was from the first and long remained the most experimental of biological sciences; necessarily experimental because it is concerned with the study of function. Before the end of the last century it had, as you know, accumulated an impressive body of enlightened knowledge concerning the visible functioning of organs. It was in the service of classical physiology that modern biochemistry had its more immediate origin. In its studies of metabolism physiology necessarily entered the chemical field and though for a long time such studies were somewhat superficial, largely because adequate chemical knowledge was lacking, they prepared the way for the more ambitious efforts of biochemistry to-day.

It is true that in Germany the chemical side of physiology was studied for its own sake and in continuity right from the days of Liebig onwards. This was the case in the University of German Strassburg. Here alone for many years was the subject of physiological chemistry recognized as entitled to recognition as a self-standing scientific discipline, and especially under the influence of the genius and the highly trained mind of Felix Hoppe-Seyler much fine work was done at that center, even during the years of which I have been speaking. At other centers in Germany great physiologists were also concerned with the chemical side of their subject; but there was only rarely any contact between the chemist proper and the physiologist. Until the end of the century the progress of biochemistry remained relatively slow and for the most part consisted in a gradual increase in knowledge concerning the general nature and distribution of the many chemical substances which are to be found in animal and plant tissues. There was also continued enterprise in studies of the metabolic balance sheet of the human body which incidentally led to much, but rather detached, knowledge concerning the end products of metabolism. Little, however, became known of the actual chemical events which occur in the tissues during life.

Apart from the divorce between chemical and biological thought, there was a tendency in the latter which in itself discouraged attempts to probe the secrets of living cells by chemical methods. Most biologists were content to ascribe the internal events of metabolism to the elusive properties of an entity insusceptible of profitable analysis; to the influence of protoplasm as a whole. There was, as I well remember, a wide-spread feeling that chemical studies which interfere with the full integrity of protoplasm could at most have chemical interest and must remain without bearing on the realities of biology. Looking back I find it interesting to recall that it was just when the last century was giving way to this that certain advances occurring together within the space of a year or two greatly helped to change a point of view which for the chemist had been wholly inhibitory. I would instance the publication of Emil Fischer's brilliant work on the chemistry of proteins, the discovery of hormones, and in particular the recognition, too long delayed, of the fact that the progress of chemical events in the living cell is controlled by definite objective agencies, the enzymic catalysts. These and other aspects of new knowledge, revealed together at a critical moment, started biochemistry in its more

modern guise on a period of rapid progress which to-day is even accelerating.

Lest they should be unfamiliar to some, I will venture to put before you in fewest possible words an appraisement of the present position and outlook of this branch of science and will endeavor to convince you that its facts are significant.

From the first, modern biochemical inquiry has had ambitions beyond that of determining the nature of the materials with which the processes of life make play, essential as such knowledge is for its progress. Its claim to be an independent branch of inquiry is and must be based on success in describing the molecular events which underlie the manifestations of life wherever they occur. It is dealing, and must deal to the best of its ability, with the living and not with the dead. Success in such endeavor is recent but is not to be thought of as altogether new. During many years a few individual workers dealing chiefly with evidence yielded by the intact organism doubtless brought to light facts bearing significantly upon the nature of chemical events as they occur within the living tissues. But such workers have till recently been rare, and the facts won were too isolated to form a significant body of knowledge. The last twenty-five years, however, have seen, together with important advances in technique, an extraordinary growth of interest in the chemical dynamics of living tissues. Recruits to their study have become very numerous, and publications concerning them appear in large numbers. There is now much knowledge of a consistent and coherent kind, as well as a large harvest of facts ready to fall into place as knowledge further advances.

You will not expect in a brief address any discussion of technicalities either of methods or results. I will deal with certain aspects of the newer knowledge on the broadest lines possible. How many and how diverse are the chemical reactions which support even some of the apparently simplest displays of function—the contraction of a muscle, for instance—is becoming daily more evident. Many of these individual reactions are being isolated from living systems and maintained in progress for successful study *in vitro*. They are found to progress because controlled by specific catalysts—the intracellular enzymes—and knowledge concerning the nature of these activating agencies, though far from complete, is rapidly growing. In not a few instances it has proved possible to follow *in vitro* reactions still proceeding in that ordered sequence which (as we have now a right to assume) reproduces their essential relations in life. In particular has success been met in the study of reductions and oxidations in living cells; all important among biochemical reactions as providing energy at the right time and in the right place for the physiological functioning of each cell or organ.

Important to productive thought about such matters is the growing assurance that the structure and configuration of molecules, which organic chemistry determines to-day with increasing accuracy and in great detail, have as great a share in deciding the origin, the influence and the fate of substances in living systems as it has in the laboratory. This was formerly disbelieved or ignored by those who were content to ascribe all chemical events in a living cell to the influence of protoplasm as an entity; real in its activities only when intact. The biochemical outlook could not fail to be widened and chemical thought concerning living organisms stimulated when physiological studies first revealed the existence of hormones and the general nature of their functions. In this field, in the specific activities of hormone, and of vitamins—which can be justifiably spoken of as exogenous hormones—we have outstanding examples of the dominant influence of molecular structure, which in the case of many of these agencies is already known. We find among them diversity of structure associated with diversity of action, and are learning that, just as in the laboratory, so in living systems, there is first the influence of molecular type and then the added influence of special atomic groupings. Also as in the laboratory certain modifications in the molecule may have relatively little influence upon its physiological activity; others may profoundly modify it. It is well to recognize how dominant is this influence of molecular pattern—the special concern of the chemist—throughout the realm of life.

Biochemical studies, owing to their early origin from the medical field, have long dealt chiefly with the mammal. If, however, the science is to arrive at significant generalizations, to decide, for example, what, in a chemical sense, is essential to the fundamental manifestations of life, and what is only essential for some specialized function, it must extend its studies into fields as wide as possible. Fortunately, associated with growing activities in the field of general physiology, there is to-day an increasing interest in comparative biochemistry, and much of fundamental importance is being learned from its pursuit. Comparative studies have led to an acute realization of the fact that biochemistry can render important help towards an understanding of development, of evolution and of heredity. Chemical differentiation underlies, or is associated with morphological and functional differentiation, and to learn exactly what is the nature of such association is a fascinating task ahead. Of great promise for future studies is the recent proof, first that definite chemical substances are concerned in evoking specifically important stages in the morphological differentiation of the growing embryo; and, second, the indication that recognizable

chemical factors, present in the genetic constitution of germ or sperm, are concerned in the carriage of the hereditary characters which appear in the developed organism. Further, we find in passing from one group of organisms to another that a given chemical function may be served by different though related substances. There is a chemistry of species. To all such conclusions the study of the plant is contributing no less than that of the animal. Much aid to biochemical thought, moreover, is coming from the studies of micro-organisms; studies which deal with them not from the standpoint of pathology, but from that of general biology; recognizing them as living systems with chemical activities and potentialities which partake of the marvelous. The field of biochemical investigations has now indeed become very wide. It would seem that chemical thought must accompany biological thought wherever it is employed.

So rapid a review as that I have put before you provides but a poor measure of the amount of progress made, but for those who were not previously familiar with the aims and activities of a relatively new branch of science it will perhaps suffice as an indication at least of their nature.

I would like to remark here that, partly perhaps because of the special interest involved in the constitution of substances so remarkable in their functions as hormones and vitamins, many eminent organic chemists with their special intellectual equipment have of late been attracted into the biological field, and other aspects of biochemistry are receiving increasing attention from highly qualified physical chemists. No branch of science will benefit more than biochemistry from those newer methods of study and newer conceptions which chemistry is just now receiving from physics. All this is of happy augury. So many problems await the united efforts of the physiologist and the pure chemist with the specialized biochemist acting as a necessary intermediary.

To the branch of science of which the aims and claims have been before you the contributions of American workers have been exceptionally great. All those, like myself, to whom it has been the concern of a lifetime owe a deep debt to this country.

At a time when, save in Germany alone, the subject was receiving scant attention in Europe, where academic recognition of its needs was almost absent and workers very few, many able investigators were already engaged upon its problems here. Posts, moreover, were provided for them at not a few centers carrying titles which implied that the subject was worthy of regard as an independent scientific discipline, a recognition then rare elsewhere. The lead given to it in America is clear to those directly concerned with biochemistry, and it is made patent to all readers of Dr. Russell H. Chittenden's admirable bo "The Development of Physiological Chemistry in United States." In that book it is also made cl how, and by whom, the seeds were sown from wh grew that early wide and generous interest in subject. They were sown by Dr. Chittenden hims So far back as 1874 he was placed in charge of t first definitive laboratory of physiological chemist in America which had its place in the Sheffield Sci tific School at Yale University. This was but a sm beginning, and at that time Germany alone co provide the knowledge and experience necessary f the teacher and investigator. The year 1878 ther fore found Chittenden at Heidelberg working und Willy Kühne, in whose laboratory the knowledge an experience then available were present in full mea sure. It is interesting to learn from Dr. Chittende that his choice of Heidelberg was intuitive. It w an intuition which fully justified itself. With th experience gained, and with Kühne's inspiration adde to his own innate gifts, Chittenden returned to a cha of physiological chemistry at Yale, a post which h occupied for forty productive years.

Much good work was done during the last tw decades of the nineteenth century, but, as Chittende himself points out, the study of the subject was lim ited in outlook till near the end of that period, b cause it was taught almost exclusively from the stand point of medical needs. Medicine has been the foste parent of the biological sciences and can thus clai their loyalty, but medicine has sometimes kept them too long in leading strings; not always realizing thei capacity for independent growth. It was mainly with dead materials and the composition of secretions and excretions that physiological chemistry was mainly concerned, subserving the then limited demands of medicine. Only a few—in America, for instance, Newell Martin and Chittenden—foresaw that its potentialities were much greater and urged that it should widen its activities. I have earlier claimed that it was just at the turn of the century that biochemistry entered upon a new period of growth and undertook its more dynamic studies. This is well illustrated by the circumstance that in America a number of brilliant investigators rather suddenly entered the field in the opening years of the present century.

I would very much like to pay a tribute to some of these. So many are worthy of mention, however, that it is difficult to avoid the invidious task of selection. Perhaps you may let me mention a few to whom I myself was especially indebted in those days, confining my references rather strictly to those whose work was in progress before the end of the first decade of the century. These were pioneers in the newer phase of biochemical progress. I will begin by mention of

Christian A. Herter, whose work began and, alas, also ended during the period with which I am dealing. Directly and indirectly Herter served biochemistry well; directly by his own work, indirectly in many ways, but especially in two. The *Journal of Biological Chemistry,* which he founded and financed, has for more than thirty years continued to publish the results of researches, very many of which are among the most important ever carried out in the subject. But Herter also fostered the genius of Henry Drysdale Dakin, and for that our debt to him is great. Dakin during the period of which I speak brought to the field of biochemistry great technical skill inspired by real chemical vision, together with an instinctive grasp of the nature of biological problems. He has never ceased to serve the subject nobly. I will next mention one who was a senior among these pioneers. His classical work upon the endocrine secretions began before the century, but it continued during those first ten years. He has done much admirable work since and has guided the thought and work of many younger men into profitable channels. To John J. Abel biochemistry owes much. The work of Otto Folin at Harvard stands out especially because of the help it gave, then and afterwards, to the efforts of others. In the fertile production of new methods of analysis Folin was supreme. Apart from this, however, our knowledge of metabolism would have had serious gaps had his own fine work been lacking. Lawrence J. Henderson's thought and work were in full activity during the period of which I am thinking, and just at its close appeared a classical publication on the equilibrium between bases and acids in the animal body which led the thought of every biochemist along new and productive lines. What he did then, and all that he has done and taught since, called for that rare and philosophical quality of mind which he possesses in full measure. Thomas Burr Osborne's invaluable work on the chemistry of proteins which began before, but continued through these years, can never be forgotten. His extraordinarily profitable partnership with Lafayette B. Mendel to which we owe so much of our knowledge concerning the biological value of proteins began just after the decade closed, but I may be allowed to pay a tribute of admiration to the enterprise. The work of Henry L. Wheeler and Treat B. Johnson at Yale, and the later work of the latter alone on the pyrimidine bases, involved constitutional studies of the highest value to biochemistry, and equally valuable was that of Walter Jones, at the Johns Hopkins University, on nucleic acid and related subjects. The work of Phoebus Levene during those early years was also devoted to nucleic acids and was most valuable. The brilliant and innumerable constitutional studies he has carried out in later years represent great accomplishment. From the Hull Physiological Laboratories A. P. Mathews was publishing his earlier researches dealing with physicochemical problems of much interest.

Apart from the work of those recognized officially as biochemists the subject in those days was benefiting greatly if indirectly, from the all-important calorimetric studies of Francis Benedict and Graham Lusk. To personal friendship with the latter and to the stimulating influence of his thought I myself owe more than I can tell. From his great book on nutrition I have derived many a lecture to students; I fear without due acknowledgment.

In the years which have followed on this pioneer period biochemistry in America has received increasing recognition, and in the hands of very many highly qualified investigators, working at numerous centers, has achieved remarkable successes. Among the many who have helped this recognition and contributed to the high accomplishment the nature of this occasion allows me the pleasure of mentioning just one. I have remarked already that, recently, the professed biochemist has fortunately gained the interest and the help of eminent organic and physical chemists which, except for the great services of Emil Fischer, it for a long time lacked. Among these is one who is equally eminent in both these branches of chemistry; I mean the distinguished president of Harvard University. Dr. Conant's work on chlorophyll and on blood pigments is of outstanding importance, and no less important are his enlightened studies of reduction and oxidation potentials which bear with the utmost significance on urgent biological problems. No one who takes pleasure in the growth of the subject can fail in gratitude to the president.

The activities which have been and are so notable in this country are now extending to every land where science is cultivated at all, and the attention given to biochemical problems is everywhere still increasing. Seldom, I think, in the history of science has any branch of inquiry enjoyed so great an impetus.

What, you may ask, from the standpoint of pure knowledge is the goal of these intellectual activities and what will be their ultimate accomplishment? I have faith that in the end they will reach to a description of living systems which, in so far as they are chemical systems, may be complete. From a knowledge of individual events they will proceed to an understanding of the organization of these events; that organization which makes the organism. I can see no obstacle to the attainment of such an intellectual synthesis of knowledge. When that synthesis comes it will involve a full understanding of many of life's visible manifestations, which is of course not to say that it will define life itself.

If, however, the claim of biochemistry is to describe life, at any level, in chemical terms it may come more under the eye of philosophy than perhaps any other branch of biology. There are schools of philosophy which will continue to ignore facts of a kind accessible to the chemist as being without significance in their search for reality; but there are other schools which will at least take note of them. In any case there are biologists with philosophical leanings who still suspect that biochemical facts are of chemical interest only.

The chemist on the other hand hopes to gain real understanding from his own standpoint of whole organisms through his study of their parts.

But these are days in which there is much insistence on the view that in the world-scheme only wholes can partake of reality. The truth that the whole is something different from the arithmetical sum of its parts, felt vaguely, but almost instinctively, even by commonplace and uninstructed minds, has been sublimated and raised to the status of a philosophical doctrine.

It is impossible at Harvard to forget the teaching of that profound philosopher, Alfred Worth Whitehead, who came one day to Cambridge from Cambridge. We have his assurance that the conception of organism must replace in thought the abstract entities which were the units of Newtonian physics. Reality always involves relations, internal and external; while an event, and not any static entity is the unit of things real.

Biology from its very nature has never been much tempted to abstraction, and for it the organism has always been the only significant unit; while the living organism as it exists in time is essentially a directed event. The question that arises is whether the modern biochemist, in analyzing the organism into the parts which he is best able to study, has so departed from reality that his studies have no longer biological meaning. I myself would venture to answer that question by saying that so long as his analysis involves the isolation of events, and not merely of substances, he is not in danger of such departure. We should learn little about the nature of an organism by being shown a collection of every substance it contains in stoppered bottles, however well known the constitution of each. Each isolated event on the other hand partakes, at least, of the nature of the whole organism. Even if on occasion it is but a single specifically catalyzed biochemical reaction it remains an event controlled and directed. True it has lost the influence of the environment which is provided by the whole organism, and its progress may thus be modified in detail, but in detail only, not in its essential nature.

I do not find that Professor Whitehead doubts the validity of such an approach to the biological whole through its chemical parts. In his Lowell Lectures published in the book, "Science and the Modern World," while claiming that, because of its concern with organism, the physiological standpoint "put mind back into nature" he remarked that "viewing the question (of organism) as a matter of chemistry, there is no need to construe the actions of each molecule in a living body by its exclusive particular reference to the pattern of the complete living organism." He suggested that each molecule may be so affected by the pattern of the whole living system as to be otherwise than what it would have been if placed elsewhere; but remarked that "it would be entirely in consonance with the empirically observed action of environments if the direct effect of aspects as between the whole body and its parts were negligible." It is true, of course, that no molecule when actually playing a part in dynamic events within an organism remains the same as when it contributes to the contents of a bottle on the shelf of the chemist. It is different because it is activated, and may be undergoing transition. The precise state at a given moment of every molecule in a living cell is doubtless determined by the state of the whole cell at that moment. Such relations, however, though so complex, are not of a kind which need escape the ultimate power of experiment to define.

It is sure, I think, that biochemical facts and biochemical thought will provide fresh aspects for biological thought. They will no less strengthen the ability of biological science to serve humanity.

It is sure that if he can add to what the eye itself reveals an adequate mental picture of the invisible molecular events which underlie the visible, the biologist will gain increased understanding of the behavior of every living thing. The physiologist too will add to his understanding of every organic function; and the clinician, no less than the pathologist, will acquire a deeper insight into the significance of every departure from the normal. This is my faith, and I hope it may be yours.

SCIENTIFIC EVENTS

VISCOUNT GREY MEMORIAL

THE following appeal, setting forth the form of the memorial by which it is proposed to commemorate the late Viscount Grey of Fallodon, has been issued:

More than two years have gone by since the death of Lord Grey of Fallodon. The time has come when the affection and admiration which he inspired among so many of his countrymen should find expression in some permanent memorial.

He is remembered as the statesman who fought so long and so hard the losing battle for European peace; and

who, amid the blinding passions of war, with failing health and eyesight, never lost his mental vision of two main principles of his practical idealism, the necessity of friendship between the British Empire and the United States, and the necessity of some collective security for future peace, which from the first he strove to see embodied in a League of Nations.

He is remembered also as the lover of nature. In writings that combine the poetry and the science of bird observation, he has taught many to find the purest and most lasting joys of mind and heart.

Yet the two aspects of his life are not to be dissociated. If the strength, integrity and simplicity of his character made him for eleven years the notable representative of his country before the world as foreign secretary, and helped to give to the British Empire and her allies confidence and unity at the supreme crisis of fate, these qualities were drawn from the same well-springs of old English rural life which inspired him as a countryman, a naturalist and an author.

We therefore propose to erect to his memory a threefold memorial:

1. To set up a statue or bust in a central spot in London.

2. To acquire and make over to the National Trust "Ross Castle," the small hill-top crowned by an ancient earthwork which adjoins Chillingham Park in Northumberland, a favourite view-point of Lord Grey's, which he often visited from Fallodon.

3. To develop (by further endowment and otherwise) the existing scheme of research maintained by the British Trust for Ornithology at Oxford, of which university he was an undergraduate and in later years the chancellor, to form a permanent Institute of Bird Studies, to which his name would be attached.

STANLEY BALDWIN
COSMO CANTUAR
CREWE
G. M. TREVELYAN
HALIFAX
(Chancellor of Oxford University)
A. D. LINDSAY
(Vice-Chancellor of Oxford University)

Subscriptions from the United States may be made payable to J. P. Morgan and Company and sent to that firm at 23 Wall Street, New York City.

IN HONOR OF WILLIAM HALLOCK PARK

DR. WILLIAM HALLOCK PARK, Biggs professor of preventive medicine, professor of bacteriology and director of the bacteriological laboratories of the New York University College of Medicine, and for forty-one years until his retirement last December director of the bacteriological laboratories of the New York City Board of Health, has been granted leave of absence for a year, after which he will become professor emeritus. The council of New York University has adopted the following minute:

William Hallock Park, born in the City of New York, December 30, 1863, was graduated from the College of the City of New York in 1883 and obtained the degree of Doctor of Medicine at Columbia University in 1886. After serving three years at Roosevelt Hospital he went to Vienna for a year of post-graduate training, returning to New York in 1890 to assume practice as a specialist in diseases of the ear, nose and throat. At the same time he carried on research at the College of Physicians and Surgeons, and made a special investigation of diphtheria through the technique of bacteriological diagnosis at the Willard Parker Hospital which commanded the interested attention of Dr. Hermann M. Biggs, who at the time was a professor in the Medical College of New York University and also in charge of an important division of the New York City Health Department. As a result Dr. Park was appointed bacteriological diagnostician of diphtheria in the department, and director of its research laboratory in 1894. There, under his direction, the first municipal bacteriological laboratory was inaugurated, and methods of diagnosis, investigation, control and prevention of disease were originated which have since been adopted the world over. This venture into the field of public health marked a turning point in his career. For forty-two years he has continued his labors as active head of the public health laboratory, tending its growth from infancy to its present maturity as a great research institution. He has served as consulting bacteriologist to the New York State Department of Health since 1914, medical examiner in bacteriology since 1917, and consulting bacteriologist to the United States Quarantine Service since 1921.

Dr. Park's connection with New York University dates from 1898, when he was appointed adjunct professor of bacteriology and hygiene. A year later he was promoted to associate professor and in 1900 professor, a chair which he held until 1933, when he was designated the first incumbent of the Biggs chair of preventive medicine. He served for a year, ad interim, as dean of the Medical College. From 1895 to 1932, he served the Willard Parker Hospital as visiting bacteriologist, and since then in a consulting capacity. In the two institutions, the college and the hospital, he carried forward year after year intricate and intensive studies in the prevention of human ills and the alleviation of distress. The history of the science of bacteriology parallels in time the years of his career, and it is a history wherein his own name will ever be gratefully commemorated.

From his early studies of diphtheria came the development of the wonderfully efficacious antitoxin. And from such representative studies of Dr. Park as those of the tubercle bacilli, the dysenteries, the typhoid bacilli and typhus carriers, the curative value of spinal administration of tetanus antitoxin, the bacteriology of respiratory infections, the bacteriology of the pneumococcus, methods of producing immunization against diphtheria, and the treatment of pneumonia, have come incalculable benefits to mankind everywhere. But the worthiest citation of all is undoubtedly his gift to little children of immunity against the dread ravages of diphtheria. There are un-

told thousands of people living to-day who but for his work would undoubtedly have succumbed to that malady in childhood. Productivity has been the keyword of his career. Notwithstanding long hours of classroom and laboratory work with medical students, and still longer hours of meditative vigil, painstaking experimentation and patient analyses of research, he has a large bibliography to his credit representing significant contributions to leading scientific journals throughout the years. In addition he has published certain text-books that have proved to be perennially authoritative. Many of the leading bacteriologists of the country owe their training to him; indeed few there are of eminence in that field who have not at some time come under his tutelage.

Dr. Park has long been an active member of leading societies in the fields of his scientific interests in this country and abroad, and has served as president of the Society of Experimental Pathology, and the American Public Health Association. Various medals of distinction have been bestowed upon him, as well as foreign decorations and honorary degrees by four universities.

For his service as a teacher, scientist and public benefactor and for the personal qualities that have endeared him to all, the Council of New York University is enduringly grateful; and in granting him leave of absence for a year, to be followed by retirement with the designation of professor emeritus, they would express their great admiration, appreciation and affection and wish for him throughout the remainder of his years continued usefulness, and the comfort and happiness he so richly deserves.

INVESTIGATIONS OF TROPICAL STORMS BY THE U. S. WEATHER BUREAU

ACCORDING to a statement made by Dr. W. R. Gregg, chief of the U. S. Weather Bureau, an attempt will be made during the next hurricane to obtain accurate information in regard to the details of the various processes of a tropical storm. About 100 small very light instruments that automatically record conditions in the air through which they are borne have been prepared. Balloons will carry them up into one of the tropical storms that usually pass over part of the southern United States between the first of July and the middle of November.

If the "eye" of the storm—the calm area, sometimes 10 miles in diameter, in the center of winds that blow at velocities up to 200 miles an hour—passes over one of the special observation stations, the instruments will go up at about 15-minute intervals. Ordinarily they will be released every 1½ to every 3 hours, the interval depending on the path and the speed of the storm. These factors will determine also whether one, two or all three stations will take part in the program.

The instrument to be used for the observations—devised several years ago by a Belgian meteorologist—weighs only about 1¼ ounces and keeps an accurate record of conditions aloft. It fits into a little box either of thin aluminum sheet or of fabric doped with aluminum paint to make it waterproof and give a highly reflecting surface as a protection against the sun. A trap at one end lets any water from clouds or rain that may enter the box escape without touching the recording elements.

The instruments will be released at three special stations—Maxwell Field, near Montgomery, Ala., and Jackson, Miss., by the Weather Bureau, and Augusta, Ga., by the Massachusetts Institute of Technology, which is cooperating with the government in this study. The forecaster for the Eastern District of the Weather Bureau, at Washington, D. C., will give the signals for the release of the instruments and will set their schedules.

The instrument is tied at the intersection of three bamboo sticks placed at right angles to each other and attached to a small spherical balloon inflated with enough hydrogen gas to make it rise at the rate of 650 to 800 feet a minute. The light bamboo framework acts as a parachute in retarding the fall of the instrument when the balloon bursts—about 10 to 20 miles above the earth. When the balloon bursts contact is broken and no records are made during the descent. Breaking the contact at the time of the release, as well as jarring that might confuse the records on the plate, is prevented by attaching the instrument to the balloon with a rubber cord, which takes up the vibration as the balloon is launched.

Five pieces of red cloth attached to the bamboo framework are designed to attract the attention of passers-by to the fallen instrument. A tag offering payment for the return of the recording device to the Weather Bureau Station at Boston, Mass., is also attached. At Boston the glass plates will be removed and read under a microscope.

COURSES IN APPLIED PHYSICS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A NEW group of courses in applied physics designed to meet the growing demand for workers with special training for the application of physics in the solution of industrial problems has been announced at the Massachusetts Institute of Technology by Professor John C. Slater, head of the department of physics. The new course begins this autumn and is in charge of Professor George R. Harrison, director of the research laboratories of experimental physics, who has been appointed director of applied physics.

President Karl T. Compton, who as chairman of the National Science Advisory Board studied the possibilities of applying the knowledge and discoveries of science in industry, is also chairman of the American Institute of Physics, which after a study of several years has suggested the type of training that will be

most valuable for physicists who expect to enter the research, development or engineering branches of industrial organizations. In this study the requirements of a large number of industries were considered with the result that a permanent national council on applied physics was established.

Training in applied physics is expected to be especially valuable in the electrical, optical, chemical, textile, paper, printing ink, aircraft and automobile industries, as well as in oil production and refining, geology and geophysics, acoustics and metallurgy. Physical principles, for example, will enter into the development of economical railway trains, prefabricated houses, air-conditioning, the preservation of food, the processing of plastics, which include glass, rubber, paint and composition moulding materials, color photography, television and many others.

Students in the new courses in applied physics will devote more time to chemistry, metallurgy and the fundamentals of electrical and mechanical engineering. The course supplements rather than competes with the long-established course in pure physics, which goes farther into the speculative aspects of science. Thus there will be no sharp distinction of staff, subjects or students between the two fields of study, for under the new plan students will be able to follow their inclinations and aptitudes in one direction or the other through proper selection of their elective courses.

The Eastman Laboratories of Physics and Chemistry and the Spectroscopy Laboratory, one of the largest in the world, will be open to the students in this course.

THE LAST WEEK OF THE HARVARD TERCENTENARY CELEBRATION

THE final exercises of the Harvard Tercentenary celebration were in progress during the week beginning on September 14. Three of the graduate schools held tercentenary programs. The Medical School opened a two-day program of symposia and demonstrations on Monday; the celebration of the School of Dentistry was held on Tuesday. The Graduate School of Business Administration held sessions on Wednesday and Thursday; a special dinner on Wednesday of the alumni was addressed by Paul Reynaud, formerly Finance Minister of France.

The formal celebration of the tercentenary opened on Wednesday afternoon with an official reception in Sanders Theater of five hundred and fifty-one accredited delegates from universities and learned societies. The Associated Harvard Clubs met on Thursday morning, when Dr. James B. Conant, president of the university, and Professor Samuel Eliot Morison, historian of the tercentenary, reported on the package of alumni letters recently found in the Widener archives, which was sealed by President Josiah Quincy in 1836 with instructions that it should not be opened for a hundred years.

Dr. Bronislaw Malinowski, professor of anthropology at the University of London, was the orator, and Robert S. Hillyer the poet, on Thursday evening at a meeting of the Harvard chapter of Phi Beta Kappa. Hermann Hagedorn also read an ode to Harvard during the day's ceremonies.

The tercentenary exercises, including the conferring of honorary degrees on scientific men and scholars who took part in the Tercentenary Conference on Arts and Sciences, a Latin oration, an address from the Commonwealth of Massachusetts and the reading of a poem by John Masefield, poet laureate of England, will take place on Friday morning. In the afternoon President Roosevelt will speak before the Alumni Association of the university.

Concerts were given by the Boston Symphony Orchestra, conducted by Dr. Sergei Koussevitzky, on Wednesday, Thursday and Friday. The 1936 Harvard football team went through an exhibition drill on Thursday and in the evening the banks of the Charles River were floodlighted for a water pageant of the history of the university. The program on Friday morning will be held on the western side of the Harvard Yard. It is expected that 15,000 people will be present.

RECENT DEATHS

DR. JAMES BEEBEE BRINSMADE, professor of physics and chairman of the department at Williams College, died suddenly on September 13 at the age of fifty-two years.

DR. JAMES M. ANDERS, formerly professor of clinical medicine in the Graduate School of Medicine of the University of Pennsylvania, died on August 29 at the age of eighty-two years.

DR. ERNEST B. LYTLE, associate professor of mathematics in the University of Illinois, who was granted the Ph.D. degree by Yale University in 1908 and who has been connected with the University of Illinois since that time, died on September 5 at the age of sixty-one years.

BARON BERKELEY GEORGE ANDREW MOYNIHAN, emeritus professor of surgery at the University of Leeds, chairman of the British Medical Advisory Board, died on September 7 at the age of seventy years.

SCIENTIFIC NOTES AND NEWS

THE American Chemical Society, meeting at Pittsburgh, paid tribute on September 10 to Dr. Charles Edward Munroe, emeritus professor of chemistry in the George Washington University. The resolution passed reads in part as follows: "The society extends to Charles E. Munroe, our only living charter member, after sixty years of loyal service to the society, its sincere best wishes and felicitations."

PROFESSOR HENRY NORRIS RUSSELL, of Princeton University, will deliver the Josiah Willard Gibbs lecture before the American Physical Society and associated societies during the meeting to be held in New York City on October 29, 30 and 31.

THE Frederick Newton Gisborne Starr Medal was presented at the annual meeting of the Canadian Medical Association to Sir Frederick Banting and Dr. Charles H. Best, of the faculty of medicine of the University of Toronto, and to Dr. James B. Collip, of the faculty of medicine of McGill University, for preeminent services to the cause of medicine in Canada. The Starr medal was established in 1935 by the widow of the late Dr. Starr, who was for several years general secretary of the association and president in 1927.

THE Royal College of Physicians has awarded the Weber-Parkes Medal and Prize to Sir St. Clair Thomson for his work on tuberculosis of the larynx. The Moxon Gold Medal was awarded to Dr. Edward Mellanby for his work on the problems of nutrition.

THE doctorate *honoris causa* of the faculty of philosophy of the University of Graz has been conferred on Dr. Max Planck, professor of physics in the University of Berlin and president of the Kaiser Wilhelm Society for the Advancement of Science.

PROFESSOR PAUL UHLENHUTH, director of the Institute of Hygiene at Freiburg i.B., has been made a foreign member of the Royal Academy of Sciences of Stockholm in recognition of his contributions to hygiene and bacteriology.

THE German Ornithological Society at its fifty-fourth congress, held at Bonn last July, elected Dr. Robert Cushman Murphy, of the American Museum of Natural History, to corresponding fellowship.

Nature states that on the occasion of the recent celebration of the twenty-fifth anniversary of the German Statistical Society the following were nominated honorary members: Professor Sigmund Schott, director of the Mannheim Statistical Office; Dr. Friedrich Prinzing, of Ulm; Dr. Kovacs, president of the Hungarian Central Statistical Office, Budapest, and Dr. Savorgnan, president of the Italian Central Statistical Office, Rome.

DR. CHARLES G. DUNCOMBE, assistant professor at the Ohio State University, has resigned to become chairman of the department of chemical engineering at the University of Detroit.

THE department of geology of Western Reserve University, following the sudden death on July 3 of Professor Jesse E. Hyde, will become the department of geology and geography. Dr. C. Langdon White, formerly professor of geography of the School of Education, who was made professor of geography at Adelbert and Mather Colleges in June, will be acting head of the new department. Robert E. Bates, of Columbia University, and Henry F. Donner, fellow at the University of Michigan, have been appointed instructors in geology.

DR. HUGH STUART CAMERON, of Cornell University, has joined the staff of the division of veterinary science of the College of Agriculture of the University of California at Davis. He succeeds Dr. J. A. Howarth, who was killed this spring in an automobile accident.

AT the University of California, Dr. Clarence H. Cleminshaw, formerly research assistant at the Flower Observatory of the University of Pennsylvania, has been appointed assistant professor of astronomy; Franklin O. Rose, of Modesto Junior College, has been appointed assistant professor of general engineering.

DR. EDWARD W. KOCH, professor of pharmacology and dean of the University of Buffalo School of Medicine, has been made dean also of the Dental School. Dr. Elmer Heath, assistant professor of medicine, has been made assistant dean of the Medical School, and Dr. Russell W. Groh, professor of operative dentistry, has been appointed assistant dean of the Dental School.

DR. HORACE M. KORNS has been promoted to be professor of the theory and practice of medicine at the College of Medicine of the State University of Iowa, and Dr. Waid W. Tuttle has become associate professor of physiology.

DR. HERBERT O. CALVERY, now senior pharmacologist, will become chief of the division of pharmacology of the Food and Drug Administration on October 1 when the present head of that division, Dr. Erwin E. Nelson, returns to the University of Michigan. Dr. Nelson joined the Food and Drug Administration in January, 1935, with leave of absence from the university, to organize and develop a division of pharmacology. At the time of his furlough from the university, he was serving as associate pro-

fessor of pharmacology in the Medical School; he has now been appointed professor of pharmacology.

BERLEY WINTON has been made principal poultry husbandman to direct poultry investigations in the Division of Animal Husbandry of the Bureau of Animal Industry. Mr. Winton succeeds Dr. M. A. Jull, who recently resigned to become head of the poultry department of the University of Maryland.

DR. HARALD ULRIK SVERDRUP, research associate of the Carnegie Institution of Washington, has taken up his work as director of the Scripps Institution of Oceanography of the University of California.

JOHN FRAZER has been appointed secretary of the committee on science and the arts of the Franklin Institute, Philadelphia, succeeding the late George A. Hoadley.

M. GASTON GRENET, meteorologist at the Observatory and Institute of Geophysics at Puy de Dôme and since 1931 acting director, has become director of the observatory.

DR. C. L. CAMP, director of the Museum of Paleontology of the University of California, has returned to the university after a year's leave of absence, during which he made a study of museums in London, Berlin, Paris and elsewhere.

AN expedition of the American Museum of Natural History, conducted by William M. Newsom, accompanied by Earl F. Watson, vice-president of the American Surety Company, sailed from New York on September 6 for Anticosti Island in the Gulf of St. Lawrence to study the deer on the island and to make a collection of the large and small mammals to be found there. They expect to complete the work by October 15.

DR. RUDOLPH VON IHERING, in charge of all fisheries work in Brazil, recently spent several days in the Washington office of the Bureau of Fisheries conferring with the commissioner and other officers of the bureau. After leaving Washington he planned to attend the meeting of the American Fisheries Society at Grand Rapids and later to work at the American Museum of Natural History in New York as well as at several of the larger eastern universities. Dr. Stillman Wright, formerly with the Bureau of Fisheries but now associated with Dr. von Ihering at the Biological Institute, São Paulo, Brazil, is also on leave in this country at the present time.

DR. CARL E. LADD, dean of the New York State College of Agriculture at Cornell University, delivered on September 1 a lecture before the fourth International Conference of Agricultural Economists in session at St. Andrews, Scotland.

THE Harveian Oration of the Royal College of Physicians will be delivered on October 19 by Sir Walter Langdon Brown. Dr. Arthur Hurst has been appointed Harveian orator for 1937 and Dr. E. A. Cockayne, Bradshaw orator for 1937.

THE Secretary of State for Scotland announces that the office of Regius professor of natural history in the University of Aberdeen will become vacant on November 15 because of the resignation of Professor James Ritchie, who has been appointed to the chair of natural history in the University of Edinburgh. It is proposed to take steps with a view to filling the vacancy in Aberdeen, but it is not expected that the new professor will be required to take up duty before January, 1937. Applications for the chair, accompanied by two copies of recent testimonials, should be addressed to the Private Secretary, Scottish Office, Whitehall, London, S.W.1, and should reach him not later than October 31.

BY the will of the late Dr. James M. Anders, a bequest of $50,000 is made to the University of Pennsylvania for the endowment fund of the Medico-Chirurgical College and Hospital, Graduate School of Medicine, and $20,000 and $15,000, respectively, are bequeathed to the Perkiomen School for Boys at Pennsburg, and Ursinus College, at Collegeville. The residuary estate is to be held in trust and on the death of Mrs. Anders $50,000 is to go to the University of Pennsylvania, to establish the "James M. Anders Foundation" in the Graduate School of Medicine, and $15,000 and $10,000 additional each is to be paid to the Perkiomen School and Ursinus College.

THE program of afternoon lectures given at the New York Botanical Garden on Saturday afternoons at 3:30 P.M. during September, October and November is as follows: September 12: "Autumn Wild Flowers," Dr. John Hendley Barnhart, bibliographer and administrative assistant; September 19: "Foods of China," Dr. W. M. Porterfield; September 26: "Next year's Garden," T. H. Everett, horticulturist; October 3: "Bulbs to Plant for Spring Bloom," Mrs. Wheeler H. Peckham, honorary curator, Iris and Narcissus collections; October 10: "Trees by the Roadside," Dr. H. Beaman Douglass, physician; October 17: "Autumn Coloration," Dr. A. B. Stout, director of the laboratories; October 24: "House Plants," Dr. Forman T. McLean, supervisor of public education; October 31: "Over the Andes and down the Amazon," Dr. Albert C. Smith, associate curator; November 7: "Economic Philippine Plants," Theodore Muller; November 14: "Ornamental Winter Fruits," E. J. Alexander, assistant curator and curator of the local herbarium; November 21: "Building the New Garden," A. C. Pfander, assistant superintendent; November

28: "Travels through the Mountains of Colorado, Wyoming and South Dakota," Dr. Fred J. Seaver, curator.

WE learn from the *Journal* of the American Medical Association that the University of California and Stanford University have organized a Western School of Public Health to assist health departments of western states in the training of public health personnel. Social security funds are used to finance the school and the education of certain public health workers. Health officers, public health nurses, sanitary inspectors, public health statistical technicians and public health laboratory technicians in the ten western states are eligible on recommendation of their health officers for attendance at these courses, which will be given during the summer months. The object is to train those who are already employed in health departments, provided they are considered worthy of receiving additional education. Applicants for the regular work, which may lead to a degree in public health, will be asked to meet definite matriculation requirements and must be within certain specified age limits.

Current Science states that the National Institute of Sciences of Calcutta, India, will issue each year a publication under the title "Indian Science Abstracts," the sub-title being "An Annotated Bibliography of Science in India." This publication, the first part of which appeared recently, plans to include abstracts of all scientific papers published in India, as also of papers published abroad on work done in India or based on Indian material.

ACCORDING to an Associated Press dispatch from Moscow, a new program of education in the medical sciences was announced on September 9 by the Soviet government. Measures were outlined to increase the number and to improve the training of doctors, nurses, dentists and druggists. A decree by the Communist Executive Committee provided for establishment of many new schools, including junior medical schools with three-year courses and an enrolment of 447,700 students; midwifery schools with two-year courses and capacity for 13,300 students, and nursing courses for 95,000.

THE London *Times* states that many species of bacteria and microfungi have been added to the National Collection of Type Cultures of microorganisms during the past five years, and the fourth edition of the catalogue, issued by the Medical Research Council, is enlarged to 143 pages. The extensive collection at the Forest Products Research Laboratory, Princes Risborough, of wood-destroying fungi and fungi causing discoloration in timber has been made available, as have also various filterable viruses maintained in a number of medical and research institutions. A valuable collection of yeasts and other micro-organisms of importance in the fermentation industries has been presented by the executrix of the late A. Chaston Chapman. The nomenclature of that important group of food-poisoning organisms known as Salmonella occupies nine and one half pages in the catalogue. Attention is directed by the council to the continued need for the deposition of newly described species and also for fresh examples of types at present in the collection.

Nature states that thanks to the generosity of Sir MacPherson Robertson, a new building has been completed in Melbourne for the housing of the National Herbarium collections, and the transfer of material is in progress. The building is a block, approximately 100 ft. by 80 ft., containing two floors. On the upper floor provision is made for the collections (numbering some 1,500,000 sheets) and for a library of more than 10,000 volumes. On the lower floor are a museum of economic botany, a laboratory, a lecture hall and the administrative offices. The construction is fire-proof throughout; all cabinets are of steel and the main door is guarded by fire-proof devices operating automatically when the temperature reaches a certain point. The collection was commenced about 1856 by the late Baron von Mueller, and it is intended to preserve the existing division into two sections (i) Australian and (ii) extra-Australian. The former is very complete and contains a number of type specimens. The room allotted to it is 60 ft. by 35 ft., allowing for 30 per cent. expansion, or 55 per cent. if further cabinets be installed. The extra-Australian section, which is already extensive and is continually growing by exchanges, will be housed in a room 80 ft. by 35 ft.

DISCUSSION

FROM THE CORRESPONDENCE OF OLIVER WOLCOTT GIBBS

THREE volumes of manuscript letters to and from Oliver Wolcott Gibbs (1822–1908) in the new library of the Franklin Institute in Philadelphia form a delightful and informative chapter in the long history of American science. Gibbs was in Cambridge from 1863 until he retired to Newport in 1887 to continue research. He is part of Harvard's scientific life. He was president of the National Academy from 1895 to 1900, president of the American Association for the Advancement of Science in 1897, and served on the Rumford committee of the American Academy from 1864 to 1894. His researches centered on work with

the spectroscope, thermodynamics and the complex compounds of cobalt.

The one hundred and fifty letters to his friend Ogden Nicholas Rood (1831–1902) reveal Gibbs as a helpful critic and a keen observer of the great developments of European and American science.

When Gibbs planned to leave the Free Academy in New York because of the fatiguing work there, he recommended Rood for the position with this encouragement, "Here is the finest collection of optical apparatus in America" (February 12, 1863). He was deeply interested in plans for spectroscopes and a binocular stereoscope. He followed closely Louis Rutherfurd's work on spectral apparatus, for "the photographs of the electric spark were beautiful and deeply interesting" (February 11, 1862), Gibbs wrote on March 1, 1870, "There is a good chance of getting the Rumford Medal for Mr. Rutherfurd for his improvements in [astral] photography," and made many efforts in that direction. Rood was also deeply interested in this field. Gibbs reminded him on December 8, 1863, of his promise to photograph on silvered glass "to get transparent metallic photographs" because the polished silver surface should be better for stellar photography.

His various estimates of Rood's work are of interest. In 1865 he viewed Rood's results with the photometric spectroscope as opening a new field for investigation. Four years later he wrote:

> Your experiment on the refraction of conducted heat is a most beautiful and important one and must have real value for the theories of heat and sound.

In 1874, he gave encouragement to his work on magnetism; it is "very interesting and important and you must follow it up."

Later, in 1896, another matter was to the front:

> I was much pleased at your remark that the x-rays may after all be only ultra-violet rays about which we really know next to nothing. . . . Your work on the x-rays is very interesting and very valuable.

He considered Rood's paper on the specific heats of iron, copper and aluminum as a valuable contribution to science (May 24, 1898).

Gibbs's comments on his contemporaries are enlightening. Upon discussing Schellbach's paper on the attraction and repulsion of a vibrating body, he commented: "That will clear up the theory of electricity in the end" (June 12, 1870). For him, Zollner's horizontal pendulum possessed "application endless in number" (January 31, 1874). He recognized and appreciated Josiah Willard Gibbs (1839–1903), and did much to turn the Rumford Medal to him in 1880, and hoped that the academy would not lose him, for his published papers in thermodynamics had given him a splendid reputation abroad.

Talk not of the laboratory is amusing. He wrote on October 21, 1872:

> I am much interested in Trowbridge who is one of the best . . . fellows I know. You must see more of him and I know you will like him as he possesses the true scientific spirit. I have never felt much confidence in Draper's work. [Tyndall is] an excellent and attractive popular lecturer and that is all.

He chides Rood:

> You did not do what was right by Remsen! As a true scientific man he had a right to a letter testifying to his real work as an investigator without reference to any special position or to any other candidate. . . . I shall give him a hearty endorsement if he applies to me. . . . I do not know whether Gilman has ever thought of me for the place. But if I go to Baltimore I should like extremely to have Remsen for a colleague. (April 19, 1875.)

A few weeks later he wrote:

> Of course I don't want to leave Harvard for a one-horse college, but I would make many personal sacrifices for better opportunities for scientific work than I have here.

Perhaps in some instances his judgment outside of science would raise some questions. In 1890, talking about university affairs:

> I hear Mr. Low spoken of as a business man only. I am afraid that you are to have a second edition of Eliot who will run the college like a soap factory . . . without any intellectual sympathy whatever.

But there can not be much opposition to his advice to Rood, who was about to visit the Exhibition of 1876 in Philadelphia:

> Don't waste your time on the Woman's Exhibition Building which contains a mighty mass of rubbish. . . . Don't sleep in any of the hotels near the Exhibition, they are poisoned with malaria, and do not forget the quinine.

We may follow his own work. In 1869 he was writing about a new method of making gas analyses; in 1871 he was making a telescope without lenses; in 1874 he admits that he has been anticipated by Fleming in making quantitative determinations by the spectroscope. In 1896 his interests turned to x-rays, radium and the action of an electrified surface. In 1901 he wrote on the discovery of one or two active elements.

> The more I think of the present state of our knowledge about radium, etc., the more it seems to me that we are simply dealing with matter in a greater degree of subdivision, or, more accurately speaking, in smaller atoms than any matter with which we have had to deal hitherto. (April 24, 1901.)

Prominent among his correspondents are Rood, Louis M. Rutherfurd, Joseph Henry, C. S. Sargent, B. A. Gould, S. Newcomb, A. D. Bache, Waldron Shapleigh, James Dana, E. D. Cope, S. P. Langley, A. A. Michelson, Charles Walcott and Ira Remsen.

Rood wrote in 1863, "I owe my sudden elevation [at Columbia] to you," and two years later, on receipt of knowledge of his election to the National Academy of Sciences, he continued: "This high honor comes from the same source to which I owe all my advancement, namely, from yourself. . . ."

Fortunately for the historian, some of the Gibbs correspondence during the Civil War adds much to our knowledge of the working of the Sanitary Commission and the office of Surgeon General. In 1899, we are reminded by Remsen that American science is spreading her influence, and therefore, it is vital that America should be represented at the Wiesbaden meeting of the International Scientific Congress.

Nor can we pass by without mentioning that there is recorded in these manuscripts some interesting episodes in the career of the National Academy and the Washington Academy. In this connection, it is worth while to quote from a letter written by C. S. Sargent to Gibbs in 1900:

> I will do what I can to stop [Gifford] Pinchot's election, although I do not feel sure that we can do much against the weight of the Washington influence. Pinchot is subservient to Walcott. . . . It seems to me that there should be some sort of organization or understanding among the members who do not live in Washington and who are not in Government employ. Unless this is done there is great danger that the Academy will be turned into a political machine used chiefly in obtaining appropriations for the Geological Survey, the National Museum and other Washington affairs. This certainly ought to be resisted.

But the discordant notes in these volumes are few. And it is with pleasure that we leave the reading of them, the pleasure that comes from watching a great mind unfold.

RICHARD HEATHCOTE HEINDEL
UNIVERSITY OF PENNSYLVANIA

ORDOVICIAN FOSSILS FROM LABRADOR

DURING the summer of 1934 a party of students and professors from Bowdoin College and Clark University accompanied Captain Donald Macmillan on his summer trip to the Arctic. Some of the group remained in Labrador to collect plants. On August 5 they chanced to be near the southeast end of Grenfell Tickle. There[1] one of the students, William B. Brierly, who had studied geology under me and was on the watch for specimens to bring back to the laboratory, collected a sack of fossils. Some of these were from talus; others, he is sure, he collected from ledge. Through Wyatt Malcolm, acting director of the National Museum of Canada, I am informed that "so far as we are aware fossils have not previously been found near the Atlantic end" of McLellan Strait. According to Dr. Wilson the fossils described constitute "only the second 'find' of rocks of Collingwood age in the whole of Labrador and in the Arctic Islands region, the Baffinland find being the other."

Assistance in identifying the fossils has been given by Messrs. Percy Raymond, August Foerste, Rudolph Ruedemann and Dr. Alice Wilson. The best of the material was sent to Dr. Wilson at Ottawa. Quotations from her letter of acknowledgment follow:

> The material seems to be typical Collingwood, with *Climacograptus typicalis, Leptobolus insignis* and *Ogygites canadensis*. . . . I have compared your specimens with what we have from Baffinland. They are similar, as is also the matrix. . . . Your specimens are exactly similar to anything found in many excavations right here in Ottawa.

In the material were also specimens of straight cephalopods. Their genus has not been determined. One fossil appears to represent part of the head and appendage of Eurypterus. Dr. Ruedemann has agreed with the writer in this identification. Apparently this occurrence is the first recorded of Eurypterus from the Collingwood.

The rock containing the fossils is a limestone. When struck by the hammer a strong bituminous odor is noticeable. On this account the writer requested our chemistry department to analyze the rock and Professor Jesse Bullock kindly carried out the work. No large amount of "oil" was present. The analysis is nevertheless appended, together with some of Dr. Bullock's comments.

ANALYSIS OF ROCK

CaO	39.6	per cent.
MgO	1.3	" "
FeO	0.2	" "
Al_2O_3	1.6	" "
SiO_2	16.6	" "
CO_2	32.6	" "
H_2O	7.3	" "
Oil	0.8	" "
	100.00	" "

> The oil may be completely removed from a ground portion by means of carbon tetrachloride or other fat solvent. . . . A large portion of the silica may be rendered soluble by means of hot concentrated hydrochloric acid.

[1] It is hoped to obtain from Captain Macmillan the exact latitude and longitude of the *Bowdoin's* stop. Mr. Brierly's notes are not sufficient to locate the area closely.

The writer extends his thanks to all who have made this note possible, particularly to Mr. Brierly for taking the trouble to get the fossils to Worcester.

HOMER P. LITTLE

CLARK UNIVERSITY

THE ANNUAL SCIENCE EXHIBITION

THE Annual Science Exhibition of the American Association for the Advancement of Science will be held this year in the Atlantic City Auditorium, from December 28 to January 1. Already there is assured the most successful performance held thus far. This is the first time that practically all the exhibit space has been taken so far in advance.

Fundamentally the exhibition is a cooperative affair between the scientific workers of the country and those self-supporting organizations that recognize the importance of the science workers to economic betterment.

While the scientists of the country spend nearly a billion dollars a year for personal expenditures and for laboratories and equipment, probably no other class of society has such a diversity of influence on the purchases of the average citizen.

Schuster, in commenting on the influence of the Kelvin galvanometer on the development of modern electrical theory, stated that the progress of science seemed to follow the development of instruments. Certainly laboratories and equipment are vital to scientific progress. The firms and individuals spend much money and effort on the Annual Science Exhibition, and are entitled to the great interest given by the scientists at the annual meetings. This year there will be exhibits from the laboratories of Arthur Compton, Irving Langmuir, Robert A. Millikan, W. F. G. Swann and Harold Urey, among many others. From the instrument firms, industrial establishments and publishers the exhibits will be numerous and better than ever before.

Some individuals of well-established corporations have expressed the desire to keep pertinent knowledge within the corporation. It seems to me that those firms that are willing to exchange knowledge with the scientists have much to gain. Cooperation might enhance the value of promotion methods.

As an example of the interest of the exhibits one of them may be described in detail. The original gondola of the National Geographic Society-U. S. Army Air Corps stratosphere balloon *Explorer II*, a noteworthy collection of scientific instruments and other equipment and a series of eight enlarged photographs depicting the landing of the balloon after its record-breaking flight of November 11, 1935, will be the principal features of the exhibit of the National Geographic Society in Booths 4 and 5.

Due to the size of the Dowmetal gondola, which is nine feet in diameter and the largest of its kind ever built, this part of the exhibit will be placed in the center of the main lounge, opposite the society's booths. All electrical connections, manholes, portholes, landing bumper and primary rigging have been preserved exactly as they were on the day of the flight, when the big globe carried Major Albert W. Stevens and Captain Orvil A. Anderson to a new world's altitude height of 72,395 feet above sea level.

Attached to the side of the gondola will be one of the battery boxes, with its accompanying parachute, and several ballast bags, whose lead shot dust could be released by means of dynamite caps fired from within.

Among the unusual and interesting instruments in the society's booths will be the official meteorograph, which hung inside the big balloon envelope during the flight; the electrical resistance thermometer unit; the official spectrograph, with its wicker basket and parachute; the oblique and vertical cameras, and the compass.

The valve in the top of the balloon, which was operated by compressed dry gas through 400 feet of small rubber hose, will also be shown, as well as the special electrically heated gloves taken into the stratosphere by the two flyers.

In addition to the series of eight enlarged photographs of the landing of the huge balloon near White Lake, South Dakota, there will be an enlargement of a vertical photograph taken from the gondola at the highest altitude (72,395 feet) while over Parmelee, South Dakota.

A scale model of the gondola, with miniature representations of the instruments and equipment, will reveal the appearance of the interior of the floating laboratory on the day of the flight. Appropriate legends will give facts about the purpose, size, weight or construction of each item, as well as information about the balloon, gondola and rigging.

Singularly appropriate is the addition of the flag of the National Geographic Society, whose three colored bars, blue, brown and green, represent the sky, the earth and the sea. The society's flag has been carried by expeditions under the society's auspices to the greatest altitude reached by man, to the North and the South Poles, as well as the greatest depth under the sea.

The affiliated societies have very generously proffered to print items of interest about the next exhibition at Atlantic City. It is hoped that the spread of advance information will increase the attendance and enhance the color of the meetings and extend the usefulness of the association. It is hoped that advantages of registration will be so apparent that members

will register early. The admission to the exhibition will be simplified if members will wear their badges. The attendance is growing so rapidly that it is becoming more imperative to make the exhibition for the membership. However, members will be entitled to bring in the members of their families.

F. C. BROWN,
Director of Exhibits

SPECIAL ARTICLES

OVUM AGE AND THE COURSE OF GESTATION IN THE GUINEA PIG[1]

IN domestic mammals, as the horse,[2] the cow,[3] the ewe,[4,5] the sow[6] and the guinea pig,[7] in which ovulation is spontaneous, it has been found to occur late in the period of heat or even shortly after its end. As a result ova ordinarily are not compelled to await the arrival of the spermatozoa. Whatever waiting is necessary usually falls to the lot of the male cells. That this arrangement may not be without significance is indicated by the lowered fertility of the sow,[6] the ewe,[8] the rabbit[9] and the ferret[10] mated shortly before or soon after ovulation and by the abnormal development of aged sea urchin eggs.[11]

In our studies of the structural and behavioral changes at oestrus in the guinea pig it has been convenient to investigate the relationship between ovum age and the course of gestation and development in this species. A complete report can not be given until preparation and study of the abnormal embryos we have recovered has been possible. In the meantime, though, certain data bearing upon the relationship between ovum age and the course of gestation have accumulated and because of their importance for problems in embryology and the physiology of reproduction they are being reported now.

Exclusive of 21 animals which did not survive the period of pregnancy, 235 individuals were inseminated artificially with spermatozoa freshly removed from the epididymides of normal males and placed in Locke's solution at room temperature. Of these, a control group of 45 were inseminated during heat and prior to ovulation. The remainder were inseminated 18, 24, 30, 36 or 42 hours after the beginning of oestrus, which may safely be assumed to be about 8, 14, 20, 26 and 32 hours respectively after ovulation.[7]

Following insemination the animals were examined twice daily for open vaginal membranes, which usually indicate that impregnation has not occurred, or for bloody vaginal orifices, which have been found to indicate that fetal death has occurred and gestation is to be terminated prematurely. When an instance of the latter was detected the female was killed immediately and the uterus with its contents and the ovaries removed for examination, fixation and subsequent microscopical study. Except for the individuals that were killed because of an abnormal pregnancy, no animal was removed from the colony until the last litter was born. This precaution enabled us to avoid errors of diagnosis in the few cases in which the vaginal membrane opened despite the presence of normal fetuses.

The percentage of impregnations, abnormal pregnancies (embryonic death within the first 20 days, later fetal death followed by abortion before the 66th day and stillbirths at full term) and normal pregnancies are given in Table I. In addition, the average

[1] This investigation was supported by a grant from the Committee for Research in Problems of Sex, National Research Council.

[2] W. A. Aitken, *Vet. Pract. Bull., Iowa State Coll.*, 8: 178, 1926.

[3] J. Hammond, "Physiology of Reproduction in the Cow," Cambridge University Press, 1927.

[4] E. Allen, F. F. McKenzie, J. W. Kennedy and W. K. Beare, Abs., *Proc. Am. Assoc. Anat., Anat. Rec.*, 48, Suppl.: 9, 1931.

[5] J. Quinlan and G. S. Maré, *17th Rept. of the Div. of Vet. Services and Animal Indust., Union of S. Africa:* 663, 1931.

[6] L. L. Lewis, *Okla. Agric. Exp. Sta. Bull.*, No. 96: 3, 1911.

[7] H. I. Myers, W. C. Young and E. W. Dempsey, *Anat. Rec.*, 65: 4, 1936.

[8] J. Quinlan, G. S. Maré and L. L. Roux, *18th Rept. of the Div. of Vet. Services and Animal Indust., Union of S. Africa:* 813, 1932.

[9] J. Hammond, *Jour. Exp. Biol.*, 11: 140, 1934.

[10] J. Hammond and A. Walton, *Jour. Exp. Biol.*, 11: 307, 1934.

[11] A. J. Goldfarb, *Biol. Bull.*, 35: 1, 1918.

TABLE I

IMPREGNATIONS, NORMAL PREGNANCIES, ABNORMAL PREGNANCIES AND LITTER-SIZE FOLLOWING INSEMINATION BEFORE AND AFTER OVULATION

Time of insemination	Number of inseminations	Impregnations	Normal pregnancies	Average litter-size	Abnormal pregnancies	Average number of recovered embryos
During oestrus	45	36 or 80 per cent.	32 or 89 per cent.	2.7	4 or 11 per cent.	2.0
18 hrs. after beginning ...	37	21 or 57 " "	12 or 57 " "	2.0	9 or 43 " "	2.2
24 " " "	41	20 or 48 " "	5 or 25 " "	2.2	15 or 75 " "	1.5
30 " " "	49	16 or 32 " "	3 or 19 " "	1.3	13 or 81 " "	1.6
36 " " "	42	4 or 9.5 " "	0 or 0 " "	0.0	4 or 100 " "	1.0
42 " " "	21	0 or 0 " "	.....	...	.....	...

litter size from normal pregnancies and the average number of recovered embryos and fetuses from abnormal pregnancies are given.

The decrease in the percentage of impregnations as ovum age increases is not unexpected. Interesting, however, are (1) the extreme limit of ovum viability, which is about 26 hours; (2) the limit of ovum age from which any normal individuals may be expected, which is about 20 hours; and (3) the time after ovulation when ovum age effects are first expressed, which is not more than 8 hours.

Also of interest are the smaller average litter-size in animals inseminated after heat and ovulation, and the subnormal number of embryos per female in the case of individuals having abnormal pregnancies. That these deficiencies are not attributable to any chance reduction in the number of ovulated ova is evidenced by the fact that the number of dead embryos removed often was less than the number of corpora lutea. Probable explanations, therefore, are some failures of fertilization, some embryonic deaths at stages earlier than those we have studied or both. If so, what is indicated for ova of different ages in the guinea pig is an entire range of potentialities from the possession of full developmental capacity through subnormal viability to the complete loss of the ability to be fertilized.

Of most importance perhaps is an analysis of the abnormal pregnancies from the standpoint of the time during gestation when the abnormality became evident (Fig. 1). In the guinea pig such pregnancies usually

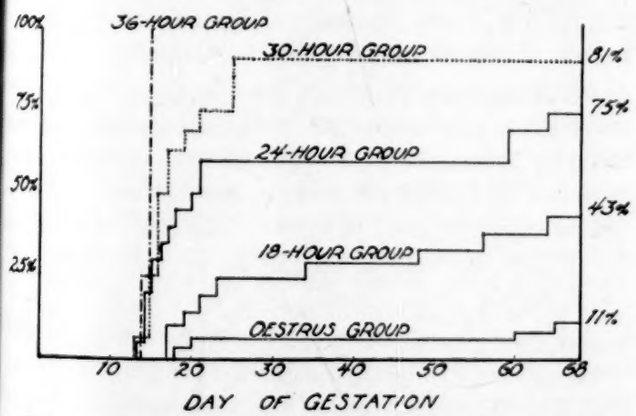

FIG. 1. Time of termination of abnormal pregnancies during the 68-day gestation period.

are terminated near the 18th, the 33rd, the 50th or the 60th to the 64th day following conception,[12] and no important number of exceptions occurred in this experiment. What was noticed, however, was a progressive increase in the frequency with which pregnancies were terminated near the 18th day and earlier as older ova were fertilized. Apparently in the guinea pig ovum age may be one cause of early embryonic death. Later deaths, on the other hand, would seem attributable to some other cause or causes because they are distributed nearly equally in the four groups in which normal litters were born. This latter conclusion, however, must be regarded as tentative until larger numbers of animals can be inseminated.

A continuation and extension of the work is intended to comprehend the gross and finer structure of the recovered dead embryos, the time of death, the nature of the original defect and an analysis of the hormonal relationship between the embryo and the corpus luteum in normal and abnormal pregnancies.

Without the generous assistance given by Messrs. John L. Boling, Edward W. Dempsey, Carl W. Hagquist and Dr. Roy Hertz in the continuous, day and night observation of the animals, completion of the experiments would not have been possible.

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[12] W. C. Young, Abs., *Proc. Am. Soc. Zool., Anat. Rec.*, 60, Suppl.: 71, 1934.

THE BLOOD IN HEMOPHILIA[1]

THE identification of a substance or substances contained in normal blood which may supply a clotting factor deficient in hemophilic blood has been the aim of these observations. The procedure consisted of adding to hemophilic blood, both *in vitro* and *in vivo*, graded amounts of normal blood and certain of its separate components. Studies made with normal and hemophilic platelet suspensions in physiological concentration revealed no differences in their behavior regarding clot production.

In normal blood and in citrated normal plasma rendered free from platelets by Berkefeld filtration, there is a substance which in small quantity effectively reduces the clotting time of hemophilic blood. This substance is either greatly diminished or unavailable in hemophilic blood and plasma.

The clot-accelerating substance in citrated normal plasma is stable for at least two months at 5° to 10° C. It is completely inactivated when kept at 56° C. for one-half hour. When normal plasma was dialyzed in Cellophane sacks against distilled water for periods varying from 12 to 72 hours, the clot-accelerating substance was found to be non-diffusible, having many characteristics of globulin. Its suspension in 0.85 per cent. NaCl solution showed a thermolability similar to that of the substance in the parent plasma.

A more practical and uniform preparation of this

[1] Preliminary report. From the Thorndike Memorial Laboratory, Second and Fourth Medical Services (Harvard), Boston City Hospital, and the Department of Medicine, Harvard Medical School.

substance was effected by dilution of plasma with 10 volumes of water and acidification with CO_2 to pH 5.8 or with 1 per cent. acetic acid to pH 5.3. The precipitate was collected by centrifuging. After resuspension in 0.85 per cent. NaCl solution to the volume of the original plasma, this substance was as effective as its parent plasma in reducing the clotting time of hemophilic blood. When the precipitate was dried *in vacuo* at room temperature a brown-grey amorphous mass was obtained. Approximately 450 to 600 mgm were derived from 100 cc of citrated plasma. The dried substance was suspended in 0.85 per cent. NaCl solution and centrifuged. The clear supernatant fluid likewise was effective in reducing the clotting time of hemophilic blood both *in vitro* and *in vivo*.

When the above procedure was applied to hemophilic plasma, an approximately equivalent amount of the dried substance was produced, the saline suspension of which, however, had little if any ability to hasten the clotting of hemophilic blood.

Tested against a freshly prepared calcium-fibrinogen system without other coagulation factors, both the normal and hemophilic precipitates were equally active as prothrombin. Our observations seem to indicate that the difference between normal and hemophilic blood is due either to a qualitative difference of their prothrombins or to other substances probably associated with prothrombin. Studies leading to the identification of this substance or to the nature of the prothrombin modification are being made.

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THE ETIOLOGY OF ULCERATIVE ENTERITIS IN UPLAND GAME BIRDS

ULCERATIVE enteritis, or so-called "quail disease," first came to the attention of sportsmen early in 1900 through the exceedingly heavy losses encountered in importations of Mexican quail. The steadily increasing demand for quail for restocking game and shooting preserves has resulted in an increased number of game farms, with a consequent concentration of birds on limited areas. Such concentrations provide favorable conditions for the transmission of the disease, and the majority of game breeders are familiar with the devastating results associated with an outbreak. Although little is known about the prevalence of the disease in wild birds, observations on native ruffed grouse in Minnesota indicate that it may be of wide-spread occurrence.

Ulcerative enteritis is a highly infectious and rapidly fatal disease that affects most species of native upland game birds. Characteristic lentiform ulcers in the intestines are the principal lesions, and the infection is readily transmitted by means of droppings. The average incubation period is about 4 days, though death may occur in 24 to 48 hours and before symptoms or lesions other than those of a toxemia have developed. A diagnosis of the disease can be established by feeding infective intestinal material to test birds. Ordinary cultural methods for isolation of the causative organism yield consistently negative results. A number of contaminating organisms, pathogenic on injection, have been isolated from diseased birds. Since natural infection, however, is contracted by the ingestion of infective material, the feeding test has remained the criterion in attempting to incriminate any organism as the causative agent.

Though a number of investigators, Morse,[1] Barger, Park and Graham,[2] Shillinger and Morley,[3] Pickens, DeVolt and Shillinger,[4] and Levine,[5] have reported on the disease in quail and grouse, no conclusive evidence has thus far been advanced to establish the etiology.

The results of our work, as reported on February 6, 1936, to the North American Wildlife Conference, at Washington, D. C., record for the first time the isolation of an organism from the liver and spleen of diseased birds that is capable of producing death and typical lesions of ulcerative enteritis when fed in pure culture to susceptible quail. Eight strains of the organism, six from bobwhite quail, one from valley quail and one from ruffed grouse, have been studied. Only slight variations in the morphological and cultural characteristics have been noted, but it appears that there may be two or more serological types. The characteristics of the organism causing ulcerative enteritis in quail are as follows:

Corynebacterium perdicum, nov. sp.

Morphology: Primary growth in nutrient broth or agar, short thick rods 0.5 to 0.8 by 2 microns occurring in clumps. Non-motile. Gram-positive. In the tissues and older cultures the organisms are gram-variable. In secondary cultures the rods are of variable dimensions, straight or slightly curved, and show metachromatic granules. Some strains exhibit a marked tendency toward pleomorphism and under certain conditions produce branching filaments, cocci, and intermediary forms.

Cultural and physiological characters: Nutrient broth: Slow growth, with increasing cloudiness and formation of viscid sediment in older cultures. Agar media: No surface growth from tissues on agar media. Primary cultures can be started in semi-solid agar or broth and

[1] G. B. Morse, *U. S. Dept. Agr. Bur. Anim. Ind. Cir.* 109, 11 pp., 1907.

[2] E. H. Barger, S. E. Park and Robert Graham, *Jour. Am. Vet. Med. Assoc.* 84 (n.s. 37): 776.

[3] J. E. Shillinger and L. C. Morley, *Jour. Am. Vet. Med. Assoc.*, 84 (n.s. 37): 25, 1934.

[4] E. M. Pickens, H. M. DeVolt and J. E. Shillinger, *Maryland Cons.*, spring issue, p. 18, 1932.

[5] P. P. Levine, *Amer. Game Conf.*, 19th, Trans., p. 437, 1932.

transplanted to plates or slants. Small circular, smooth, grayish white colonies appear in 72 hours from new cultures. When growth is established, the colonies are large, moist, and convex, with yellow pigment. The rough types are large white umbonated, leathery colonies with irregular margins that become powdery white on top in 48 hours and show no tendency to spread with age. Gelatin stab: Slight growth, no liquefaction. Potato: Good growth with yellow pigment. Loeffler's blood serum: Small, circular, colorless colonies, with slow liquefaction. Serum enhances growth of organism. Litmus milk: Unchanged. Kligler agar: Negative to slight hydrogen sulphide production. Indol test: No production in tryptophane broth. Nitrates: No reduction. Fermentation with cresol red and bromthymol blue, used as indicators: Acid produced in galactose, dextrose, levulose, maltose, sucrose, and salicin. Arabinose variable. Alkaline reaction produced in adonitol, dextrin, inulin, lactose, mannitol, raffinose, and xylose. Aerobic, facultative. Optimum hydrogen ion concentration of media: Ph. 7.6. Optimum temperature: 37° C.

Habitat: Isolated from liver, spleen, and heart blood of infected birds. Pathogenic for quail and grouse with the formation of intestinal ulcers when given per os.

The organism quickly loses its virulence following isolation, and ordinarily most of the strains become non-virulent when growth is established on culture media. The symptoms, the sudden death and the character of the lesions associated with acute cases of the disease indicate that the organism produces a potent toxin, but thus far we have been unable to demonstrate toxin production.

Under conditions on game farms there is usually a sudden onset of an epizootic with a large percentage of the birds succumbing in a short time. The disease may entirely subside or it may be followed by an occasional case of chronic infection. It is as a rule difficult to transmit the disease with infective material from a chronically affected individual. Repeated transmission of the disease from one bird to another, under laboratory environment in every instance, has tended to decrease rather than increase the virulence of the infection. All attempts to increase the virulence under natural conditions have failed.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

VINEGAR AS A SOIL DISINFECTANT

ACETIC acid, like formaldehyde, is for some purposes an effective soil disinfectant.[1] Neither remains in the soil long enough to prevent all reinfestation of soil and resulting late infection of plants by fungi, but either is useful in protecting seedlings, of all but slowly germinating species, against damping-off. Applied to soil in too large amounts and not a long enough time before seeding, either may be toxic to plants. Any delay between soil treatment and seeding is considered objectionable by plantsmen, and the relatively general use of formaldehyde dust is due as much to the fact that it may be safely applied to soil immediately before seeding as to its effectiveness.

An acetic acid dust, containing about 23 per cent. of acetic acid in a carrier of powdered wood charcoal, is apparently no less effective in controlling damping-off of seedlings caused by species of Pythium and Rhizoctonia and no less safe to plants. This has been applied to and thoroughly mixed with sandy soils, at the rate of 42 grams per square foot of soil surface. With seeds sowed immediately after this treatment of the soil, and with soil well watered at the time of seeding, acetic acid dust has had no harmful effect on growth of seedlings of *Centaurea Cyanus, Bellis perennis, Cerastium Biebersteinii, Lupinus polyphyllus,* Zinnia, China aster, *Laburnum alpinum,* cress (*Lepidium sativum*), beet and five species of Rhododendron.

Neither acetic acid nor formaldehyde is always at hand when needed by the plantsman, and this is one principal reason why seeds are often sowed without any protection against soil fungi, for convenience or the lack of it is an important consideration in practice.

Cider vinegar, as usually sold, contains 4 to 5 per cent. acetic acid or not far above the minimum required by law. There are few substances more readily available or more generally at hand than vinegar, and the writer has found it reasonably effective in the protection of seedlings against some of the damping-off fungi and at the same time relatively or quite harmless to plants, even when applied to soil immediately before seeding.

Four brands of cider vinegar have been used. Although their acetic acid contents varied from 4.1 to 5.2 per cent., with an average of 4.3 per cent., they have not differed significantly in effectiveness.

Vinegar, without dilution, was applied to and thoroughly mixed with somewhat dry and definitely sandy soils. Soils used were either naturally infested with species of Pythium and Rhizoctonia or were, some days before treatment, inoculated with these fungi. Seeds were sowed immediately or within a few hours after soil treatment and the soils were then well watered.

The degrees of protection resulting from this treat-

[1] *Jour. Agr. Res.*, 44: 571–578, 1932.

ment were in some cases a little less complete than those which followed the use of formaldehyde or acetic acid dust, but germination of seeds was usually markedly improved, by the elimination of much pre-germination damping-off, and post-germination damping-off was on the whole very well controlled by 200 to 250 cc of vinegar per square foot. The quantity of vinegar necessary for satisfactory control of these diseases was apparently affected by the degree of infestation of the soil by the fungi, naturally contaminated soil being a less severe test than is soil autoclaved and artificially inoculated.

One-half pint (about 237 cc) of vinegar per square foot of soil, 3 inches deep, was usually enough for satisfactory, sometimes complete protection, with the number of living plants often increased many fold. Seedlings were weighed at that stage of growth at which they are usually transplanted for the first time, and this quantity of vinegar in the soils used had no retarding effect on growth of seedlings of *Calendula officinalis, Dianthus arenarius, Centaurea Cyanus, Lupinus polyphyllus, Iberis umbellata, Cheiranthus Allioni, Verbena hortensis, Dimorphotheca aurantiaca, Mesembryanthemum criniflorum,* China aster, beet, cabbage, lettuce and tomato.

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A METHOD FOR THE MEASUREMENT OF ACTIVITY OF SMALL ANIMALS

WHILE the running wheel has proved satisfactory for the study of the quantitative aspects of the activity of rats, the usual method of recording activity of other small animals by a vertically moving kymograph lever connected with the activity cage has not permitted adequate quantitative description. The apparatus described combines the method used by Skinner[1] in obtaining a distance-time graph of the activity of a rat in a running wheel and that of Szymanski,[2] which employs a cage suspended by a spring.

A cage (A) 1 ft. square on the bottom constructed of $\frac{1}{8}''$ wire mesh is suspended by a spring (S) of the type used for small bird cages. The arm of a physiological work adder (W) (Harvard Apparatus Co., Boston) is connected by a string with the center of the cage bottom, so that any movement of the cage will cause a turning of the ratchet wheel of the adder. Rotation of the adder winds a string connected with a reducing gear (G), which in turn causes an upward movement of a pen (P) recording on a kymograph drum. (K) (A pulley wheel of $1\frac{1}{4}''$ diameter on a $\frac{1}{4}''$ axle served satisfactorily as a reducing gear.)

[1] *J. Gen. Psychol.*, 9: 3–24, 1933.
[2] *Pflüger's Arch.*, 171: 363–373, 1918.

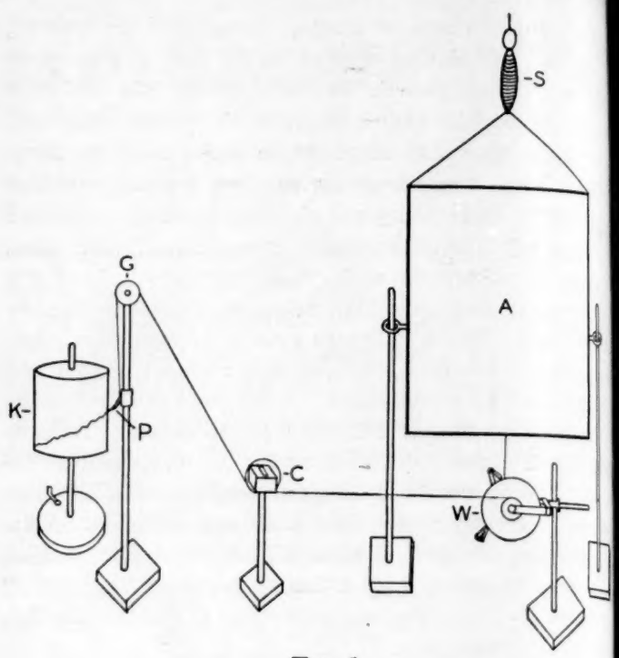

FIG. 1

This type of record differs from the usual one which records each movement as a vertical rise and fall in that the graph rises during activity and moves horizontally during rest. The result is a cumulative vertically rising graph. It will be evident that the more violent the activity the more rapid will be the rise of the curve; and the height of the curve at any point will be proportional to the total activity up to that time. Mr. Herman Von Dach of this laboratory suggested the use of the Veeder counter as another means of measuring the total activity. This can be operated by the thread connecting the adder with the reducing gear looped around a pulley wheel placed on the shaft of the counter (C). When a kymograph record is not desired the writing unit can be disconnected and the counter attached to the adder by a pulley.

The specifications given have been found satisfactory for the study of activity of chicks. Modifications in cage construction, strength of spring and gear ratio make the method adaptable to animals of larger or smaller size.

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BOOKS RECEIVED

CROSS, P. G. *Our Friends the Trees.* Pp. 322. 41 plates. Dutton. $5.00.

LINTON, RALPH. *The Study of Man; An Introduction.* Pp. ix + 503. Appleton-Century. $4.00.

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